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Technical Note N-1291

ZINC-RICH COATINGS FOR ALUMINUM IN SEAWATER

By

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August 1973

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YF 54.543.006.01.002

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ABSTRACT

Aluminum 6061-T6 coated test panels were prepared for exposure in the harbor water at Port Hueneme, California. Surface preparation of most of the panels was by a light sandblast before application of selected coatings; but one series was merely washed clean with water and then with mineral spirits, and another was treated with Alodine 1200S before the coatings were applied. Zinc-rich primers of various types were used, topcoated with epoxy vinyl or coal-tar epoxy systems. After three years of exposure coatings over the Alodine 1200S gave good to excellent protection comparable to that over the zinc inorganic silicates. The topcoated zinc-rich organic primers were slightly inferior to the zinc inorganic silicates. Several coating systems gave excellent protection during the three years of harbor exposure and indicated a protective potential for several years more.

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INTRODUCTION

Because of the rapid corrosion of aluminum in seawater, structures, devices or apparatus fabricated from aluminum for use in a seawater environment are designed for short life cycles. Some aluminum alloys are attacked severely within six months of exposure in seawater.[1] It was found that because of either pitting or crevice attack or both and the lowering of mechanical properties, aluminum should not be used in seawater applications without suitable protection.[2] Sacrificial zinc anodes were found satisfactory for preventing pitting, crevice and galvanic corrosion of 6061-T6 aluminum.[3] Also, a paint system protected the 6061-T6 aluminum for more than six months.[3] Zinc-rich organic coatings were found satisfactory for protecting steel in a deep ocean environment for over six months.[4] Because zinc anodes will protect aluminum, and zinc coatings were compatible with an aluminum substrate, investigation was initiated to determine the effectiveness of zinc-rich coating systems in giving long term protection to 6061-T6 aluminum.

For this investigation, eight different zinc-rich coatings, six different topcoats and three different surface preparations were combined to give forty-five protective coating systems. Each of these systems was applied to a set of four 6 x 12 x 1/8 inch 6061-T6 aluminum specimens. One side of each coated specimen received a scribe cut through the paint film so as to expose the bare aluminum.

Two panels of each coating system were placed on the deep ocean Submersible Test Unit (STU I-6), exposed off the coast of California near Port Hueneme in about a 6,000 foot depth of ocean water. The remaining two specimens of each coating system were exposed in shallow ocean water in the Port Hueneme Harbor entrance channel, at about a one foot depth at low tide.

The specimens emplaced in 6,000 feet of water on STU 1-6 have been on exposure for over three years because of inability to retrieve the STU.

The specimens exposed in the harbor entrance were inspected, rated and photographed at the second and third annual intervals. This report describes the results after three years of exposure.

TEST PROCEDURE

Panel Preparation

The test panels were 6061-T6 aluminum 6 x 12 x 1/8 inches in size. The panels were prepared and coated in sets of four, two for deep ocean exposure and two for shallow ocean exposure. Except for two series,

all aluminum panels were given a light sandblast to remove the oxide film and to roughen the surface. One of the two series not sandblasted was merely washed clean, first with water then with mineral spirits. The remaining series were given an Alodine 1200S oxidizing treatment in lieu of sandblasting.

The coatings systems are shown in Appendix A. The sources of the coatings are listed in Appendix B.

Four zinc inorganic silicates, two zinc-rich epoxies, one zinc-rich modified saran and one zinc-rich chlorinated rubber were each applied to a separate set of prepared aluminum test specimens and exposed with and without topcoats. The topcoats were the epoxies recommended by the proprietary manufacturer, a Navy vinyl system, Tarset C-200 and a proprietary epoxy, Plastic 7103/7122. The identity of each coating system is presented in Table 1. For further information see Appendices A and B.

Coatings Analyses

Laboratory analyses were made to determine physical properties and composition. Analysis procedures were based on methods specified in Federal Test Method Standard No. 141 (TT-P-141); ASTM Standards, Part 21; and Painting Testing Manual, 12th Edition, by Gardner and Sward. The physical properties determined included weight per gallon, specific gravity, and consistency in Krebs Units (KU). Composition analyses were made to determine the amounts of non-volatile solids, total pigment and non-volatile vehicle. Results of these analyses appear in Appendix C.

DISCUSSION

The protection given to the aluminum by the zinc rich coatings without topcoats will be discussed. This will be followed by a discussion of the effects of (1) the Navy vinyl and saran topcoats, (2) the epoxy topcoats and (3) the Tarset C-200 topcoat. The racks of panels as they were lifted from the water were cleaned of fouling before inspection Figures 1 and 2. Results of the two annual ratings appear in Appendix D.

Zinc-Rich Coatings and Alodine 1200S Without Topcoats

The best protection from the zinc-rich coatings without topcoats was found from the System A-4, Rust Ban 191, a self-curing zinc inorganic silicate at a thickness of 7.0 mils (0.007 inch). Although the protection after 3 years of immersed exposure was excellent the remaining coating was very thin, Figure 3. System A-1 Carbo Zinc 11, System A-5, zinc-rich saran and System A-11, zinc-rich chlorinated rubber, were

Table 1. Coating Systems Identities

First Coat	Sandblast	No Topcoat	Navy Vinyl	Tarset C-200	Epoxy	Plasite 7103-7122	Saran
	Topcoats						
Carbo Zinc 11	+	A-1	A-1-V	A-1-T	A-1-E	A-1-P	-
Dimetcote 3	+	A-2	A-2-V	A-2-T	A-2-E	A-2-P	-
Rust Ban 190	+	A-3	A-3-V	A-3-T	A-3-E	A-3-P	-
Rust Ban 191	+	A-4	A-4-V	A-4-T	A-4-E	A-4-P	-
Saran + Zinc	+	A-5	-	-	-	-	A-5-S
Enjay EX6662	+	A-6	-	A-6-T	A-6-E	A-6-P	-
Epolux E-14	+	A-7	-	A-7-T	A-7-E	A-7-P	-
Alodine 1200S	-	A-8	A-8-V	A-8-T	A-8-E	A-8-P	-
(Sandblast)	+	-	A-9-V	A-9-T	A-9-E	A-9-P	-
Solvent Wash	-	-	A-10-V	A-10-T	-	A-10-P	-
Chlorinated Rubber	+	A-11	-	A-11-T	A-11-E	-	-

giving good protection at this time but numerous instances of light pitting of the aluminum substrate and flaking of the coating along the scribe were observed. The only fouling damage was with the chlorinated rubber, System A-11. Good to fair protection of the aluminum panels was observed after 3 years from System A-6, Enjay EX6662, and System A-7 Epolux E14, both zinc-rich epoxies. Medium to medium dense blistering, and flaking was found along the scribe. Also, blistering over the plain areas was found on System A-7. Fair to poor protection was being given by System A-2, Dimetcote 3, and System A-3, Rust Ban 190, both zinc inorganic silicate coatings. These coatings appeared to have solubilized more rapidly than did the other two zinc inorganic silicate coatings. However, System A-3 was only 3.0 mils thick when applied versus 6.5 mils for System A-2, yet was in slightly better

condition after 3 years than was System A-2. The manufacturer of coating A-3 recommended not to apply more than one coat at 3.0 mils.

The Alodine 1200S anodizing treatment (Figure 4) without a topcoat, System A-8, failed to protect the aluminum panels in less than 1 year of exposure in Port Hueneme Harbor.

Vinyl Topcoats

The specification vinyl topcoat system consisted of pretreatment primer (MIL-P-15328B), vinyl red-lead primer (MIL-P-15929B) and a white vinyl-alkyd finish (MIL-E-16738B) applied over all zinc-rich primers except the zinc-rich saran. The Mare Island Naval Shipyard modified orange saran (3F-116-1) was applied over the modified orange saran containing zinc dust pigmentation. The zinc-rich primer coats were applied to give 3.0 mil dry film thickness. The specification vinyl-alkyd topcoat system applied over the aluminum panels, without a zinc-rich primer, utilized the vinyl zinc chromate primer (MIL-P-15930B) in lieu of the red-lead primer (MIL-P-15929) because the red lead pigmentation is not compatible with aluminum.[5]

Good protection from a vinyl topcoat system was found when applied over the following substrates: zinc inorganic silicates Dimetcote 3, System A-2-V; Rust Ban 190, System A-3-V; Rust Ban 191, System A-4-V; and the Alodine 1200S anodizing treatment, System A-8-V (Figure 5); as well as the saran coating System A-5-S with the saran topcoat. The primary cause of coating deterioration was from blistering along the scribe which varied from a few blisters to a rating of medium. Except for System A-4-V, no blistering had occurred on the un-scribed side of these panels. The vinyl system over Carbo Zinc II, System A-1-V was giving only fair protection along the scribe after 3 years of exposure in Port Hueneme Harbor, and as with System A-4-V, blisters had formed on the un-scribed side of the panels and could impair long term bonding. The vinyl over the sandblasted aluminum panels, System A-9-V, had failed by the end of the 3 years. When applied over the aluminum after only a solvent wash, System A-10-V, failure of the vinyl system occurred in less than 2 years. Thus the sandblasted surface preparation was significantly better than a solvent wash.

Epoxy Coatings as Topcoats

Slightly the best protection given by the epoxy topcoat systems was over a self-curing zinc inorganic silicate, Rust Ban 190, System A-3-P, Figure 6 and over the Alodine 1200S, System A-8-E and System A-8-P, Figure 7. The protection was excellent on both sides of these panels. Only a few blisters were found along the scribe of System A-3-P with no undercutting. The following epoxy topcoat systems gave good to excellent protection during the 3 years of exposure, Systems A-2-P, A-3-E, A-4-E and A-6-E. The latter system, A-6-E, was a zinc rich epoxy primer with an epoxy topcoat system, Figure 8. Only medium

to few blistering was observed along the scribe of these epoxy topcoated systems. Four systems with epoxy topcoats (Systems A-1-P, A-4-P, A-6-P and A-7-P) gave generally good protection along the scribe, only slightly less than the above systems. Again only few to medium blistering was observed along the scribe. However, Systems A-1-P and A-4-P showed some blistering on the un-scribed side of the panels and could ultimately cause general loss of bond.

The following epoxy topcoats were near failure after the 3 year exposure period in Port Hueneme Harbor; Systems A-1-E, A-2-E, A-9-E and A-11-E. System A-9-E had a sandblasted surface preparation only, and System A-11-E had a zinc-rich chlorinated rubber primer. Medium to dense blistering was observed along the scribes. Dense blistering indicating loss of bond had occurred in the un-scribed areas of System A-1-E, Carbo Zinc 11 with HB 190 topcoat, Figure 9.

The epoxy topcoats over zinc-rich epoxy primers, System A-7-E, and System A-9-P, had failed along the scribe by the end of 3 years and 2 years respectively. However, no failure had occurred on the un-scribed side of the panels. System A-10-P, an epoxy topcoat system over the aluminum with only a solvent wash surface preparation failed by the end of 2 years of exposure. By the end of 3 years the coating was completely gone and the aluminum was being attacked. Again, a sandblast surface preparation is much better than only a solvent wash.

Coal-Tar Epoxy Topcoats (C-200)

The coal-tar epoxy topcoat gave good to excellent protection for 3 years when applied over the zinc inorganic silicates of System A-4-T (Figure 10), Rust Ban 191 and System A-2-T, Dimetcote #3, as well as when applied over the Alodine 1200S anodizing treatment, System A-8-T. Only a few blisters were observed along the scribe and none on the unscribed surfaces. Although the coal-tar epoxy was giving good protection over the zinc-rich epoxy System A-6-T and the zinc inorganic silicate Systems A-1-T, Carbo Zinc 11, and A-3-T Rust Ban 190, a few blisters along the scribe had caused flaking of the coal-tar epoxy from the primer. No blisters were observed on the unscribed surfaces. The coal-tar epoxy topcoat over zinc inorganic silicate, System A-1-T, was giving good protection after 3 years of exposure in Port Hueneme Harbor. Blistering and undercutting along the scribe as well as blistering over the unscribed surfaces, indicated a lessening of the protective potential for this system. The coal-tar epoxy over the zinc-rich epoxy primer Rust Ban EX6662, System A-6-T, was giving good protection after 3 years of exposure with no blistering over the unscribed surfaces; however, considerable undercutting was initiated by a few blisters along the scribe.

The remaining systems with the coal-tar epoxy topcoat, Epolux E-14, zinc rich epoxy System A-7-T (Figure 11), the sandblasted surface System A-9-T, the solvent washed surface System A-10-T, failed in less than

2 years of exposure because of loss of adhesion of the topcoat. The protection was slightly better over the sandblasted surface than over the solvent washed surface. Similarly, this topcoat was near failure when applied over the zinc-rich chlorinated rubber, System A-11-T, after 2 years of exposure in Port Hueneme Harbor.

RESUME

The zinc-rich coatings without topcoats gave about 3 years of protection to the aluminum panels in Port Hueneme Harbor. The zinc inorganic silicate coatings had solubilized and except for System A-4, bare aluminum was exposed and the aluminum substrate was pitting and corroding. The zinc inorganic silicate coatings had only light to negligible fouling attachment and no fouling damage. However, some fouling attachment, especially barnacles, were found on the zinc-rich organic coatings and some fouling damage had occurred causing light pitting of the aluminum. The zinc-rich organic based coatings had a tendency to flake from the aluminum along the scribe and corrosion of the aluminum occurred. Some tendency toward blistering was observed with the zinc-rich organic based coating. Also, the best protection of the aluminum by the zinc-rich coatings without topcoats was from the Rust Ban 191, System A-4, a zinc inorganic silicate. Slightly less, but good, protection was observed from System A-1, Carbo Zinc 11. a zinc inorganic silicate; System A-5, a zinc-rich modified saran, and System A-11, a zinc-rich chlorinated rubber.

The Alodine 1200S anodizing treatment without a topcoat failed within 1 year of exposure in the harbor water at Port Hueneme.

The vinyl system over the zinc inorganic silicate primers gave good protection for 3 years in the harbor water at Port Hueneme, except for System A-1-V. This vinyl system over the Carbo Zinc 11 was giving only fair protection because of blistering over the unscribed surfaces and some flaking along the scribe. The vinyl system gave good protection when applied over the Alodine 1200S. However, only fair protection was observed after 3 years for the vinyl system applied over the sandblasted aluminum and complete failure of the vinyl system occurred in less than 2 years when applied over the solvent washed aluminum.

Five different epoxy coating systems were applied over the zinc-rich primers to give 13 protective coating systems. Five of these systems (A-3-P, A-4-E, A-6-E, A-3-E, A-2-P) representing two of the five topcoat systems were giving good to excellent protection to the aluminum panels after 3 years of exposure in Port Hueneme Harbor. These two topcoat systems were the Plasite 7103/7122 and Rust Ban EM6664/EX6670 epoxies. Six of the 13 epoxy systems were giving good to fair protection and two had failed; System A-1-E because of blistering of the epoxy coating and System A-7-E because of heavy undercutting

along the scribe. The two epoxy systems applied over the Alodine 1200S gave excellent protection for 3 years with only light undercutting along the scribe. The two epoxy topcoat systems which were applied over a sandblasted aluminum substrate had either failed (System A-9-P) or was near failure (System A-9-E) after 3 years of exposure. The epoxy applied over a solvent washed aluminum, System A-10-P, had failed after 2 years of exposure.

The coal-tar epoxy (C-200) topcoat gave excellent protection for 3 years over Rust Ban 190 (System A-3-T), and very good protection over Dimetcote 3 (System A-2-T) and Rust Ban 191 (A-4-T). Also excellent protection was obtained over Alodine 1200S (System A-8-T). Good protection was observed over Carbo Zinc 11 (A-1-T) and Rust Ban zinc-rich epoxy (System A-6-T). However, this coal-tar epoxy failed in about 2 years over both a zinc-rich chlorinated rubber (System A-11-T) and a zinc-rich epoxy (System A-7-T), and in less than 2 years over the sandblasted or solvent washed aluminum. In general the coal-tar epoxy gave satisfactory protection for 3 years when applied over the zinc inorganic silicates or the Alodine 1200S. Again, the zinc-rich primers alone at 6.0 mils gave 3 years protection to the aluminum in Port Hueneme Harbor. The following topcoat systems gave 3 years protection to the zinc-rich primers except at the scribe where bare aluminum was exposed; specification vinyl, epoxies (1) Plasite 7103/7122 and (2) Rust Ban EM6664/EX6670, and coal-tar epoxy. However, these topcoat systems had a tendency to blister when applied over Carbo Zinc 11. In most instances only light to negligible attack along the scribe was observed, probably because of the protective action of all of the zinc-rich primers. Also, the protection from the epoxies applied over the zinc inorganic silicates was superior to that over the zinc-rich epoxies.

The specification vinyl, epoxies and coal-tar epoxy applied over the Alodine 1200S treated aluminum gave very good to excellent protection for 3 years in Port Hueneme with only light attack along the scribe.

Coatings did not perform well over a solvent washed aluminum surface but did fair to failure over a sandblasted aluminum surface. The Rust Ban 191 (System A-4) zinc inorganic silicate gave the best protection of any of the zinc-rich coatings without a topcoat.

The best coating combinations tested over aluminum 6061-T6 were; (1) Plasite 7103/7122 over zinc inorganic silicate Rust Ban 190, System A-3-P, (2) Plasite 7103/7122 over the Alodine 1200S System A-8-P, (3) Rust Ban epoxy EM6664/EX6670 over Alodine 1200S, System A-8-E, (4) Coal-tar epoxy, Tarset C-200 over zinc inorganic silicate Dimetcote 3 System A-2-T.

CONCLUSIONS

From the results of harbor exposure of coatings for 6061-T6 Aluminum, it was concluded that;

1. The maximum protection rendered by 6.0 mils of a zinc-rich coating on aluminum exposed in seawater is about 3 years.
2. The specification vinyl system (MIL-P-15328B, MIL-P-15929, MIL-E-16738B) applied over zinc inorganic silicate primers (Dimetcote 3, Rust Ban 190, or Rust Ban 191) will give good protection to aluminum for over 3 years.
3. Epoxy topcoats (Plasite 7103/7122, or Rust Ban EM6664/EX6670) applied over the zinc-rich epoxy or inorganic silicate primers will give good to excellent protection to aluminum for over 3 years.
4. The specification vinyl (with the zinc chromate primer), epoxies or coal-tar epoxy (C-200) applied over the Alodine 1200S treatment will give good to excellent protection to aluminum for over 3 years.
5. A solvent wash will not satisfactorily prepare aluminum for receiving a topcoat system.
6. A light sandblasted surface on aluminum improves the protective potential of a protective coating compared to no surface preparation.
7. The Alodine 1200S treatment is an excellent surface preparation for aluminum prior to application of a protective coating.
8. The alodine 1200S treatment suitably topcoated will give protection equal or superior to a zinc-rich coating suitably topcoated over aluminum and exposed in seawater.
9. The zinc-rich modified saran (5.0 pounds of zinc per gallon) with a modified saran topcoat, System A-5-S, protective coating system will protect aluminum in seawater for over 3 years.

RECOMMENDATIONS

The following coating systems are recommended for protecting aluminum in seawater exposure for over 3 years;

1. Alodine 1200S topcoated with an epoxy such as Plasite 7103/7122, Rust Ban EM6664/EX6670, coal-tar epoxy (C-200) or specification vinyl (MIL-P-15328B, MIL-P-15930B, MIL-E-16738B),
2. A zinc inorganic silicate primer, such as Rust Ban 190, Rust Ban 191, Dimetcote 3 or Carbo Zinc 11, topcoated with an epoxy, such as Plasite 7103/7122 or Rust Ban EM6664/EX6670, or the specification vinyl (MIL-R-15328B, MIL-P-15929B, MIL-E-16738B).
3. Ratings and photographs of these test specimens should be made annually to determine long term protective potential for these systems.

ACKNOWLEDGMENT

The assistance of Mr. A. F. Curry, Senior Project Technician is greatly appreciated for supervising the panel preparations, coating applications and in inspecting and rating of the weathered specimens, as well as preparing of all tables in this report.

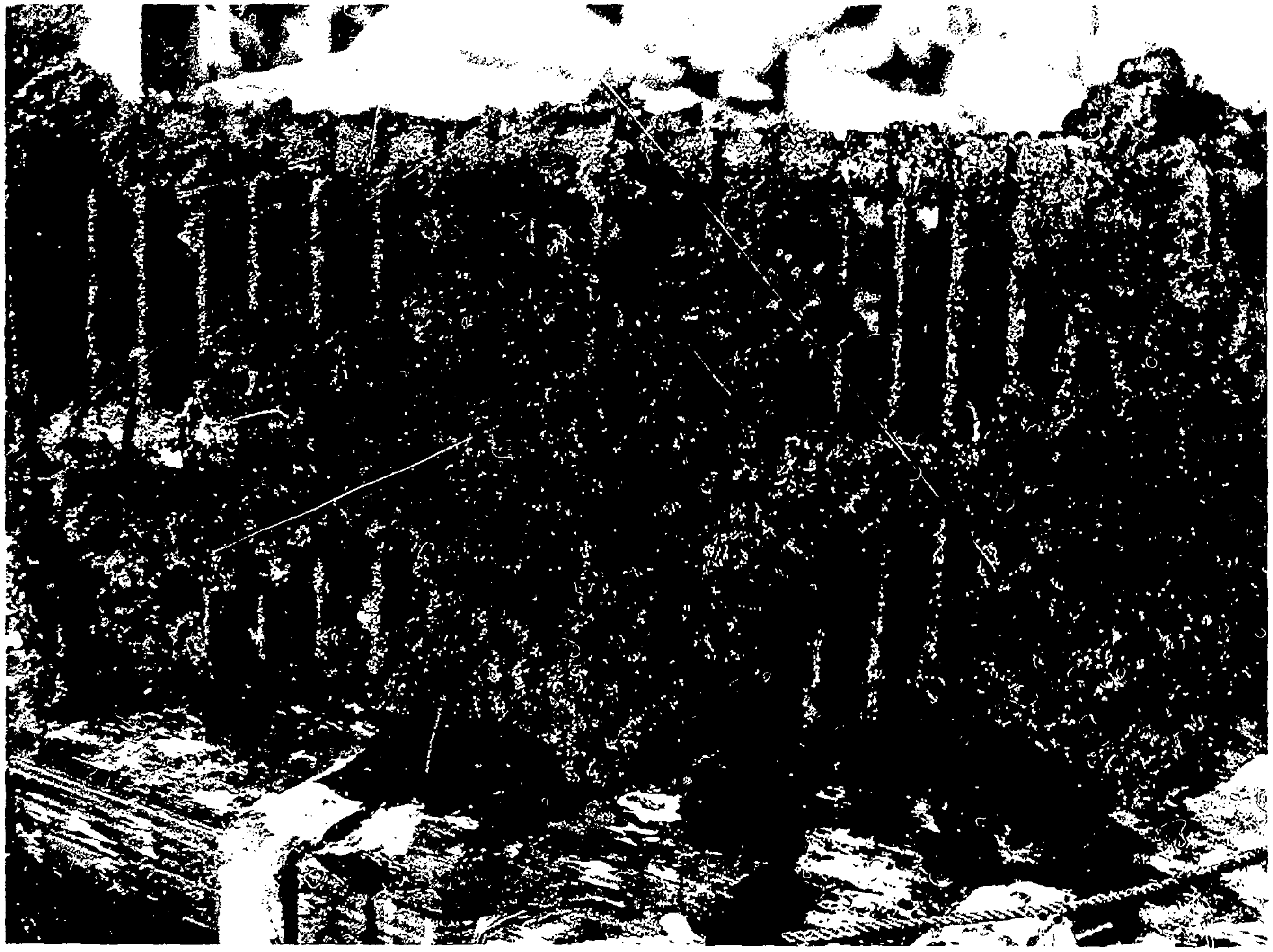

Figure 1. Rack of panels after removal from Port Hueneme Harbor, 3 years exposure.

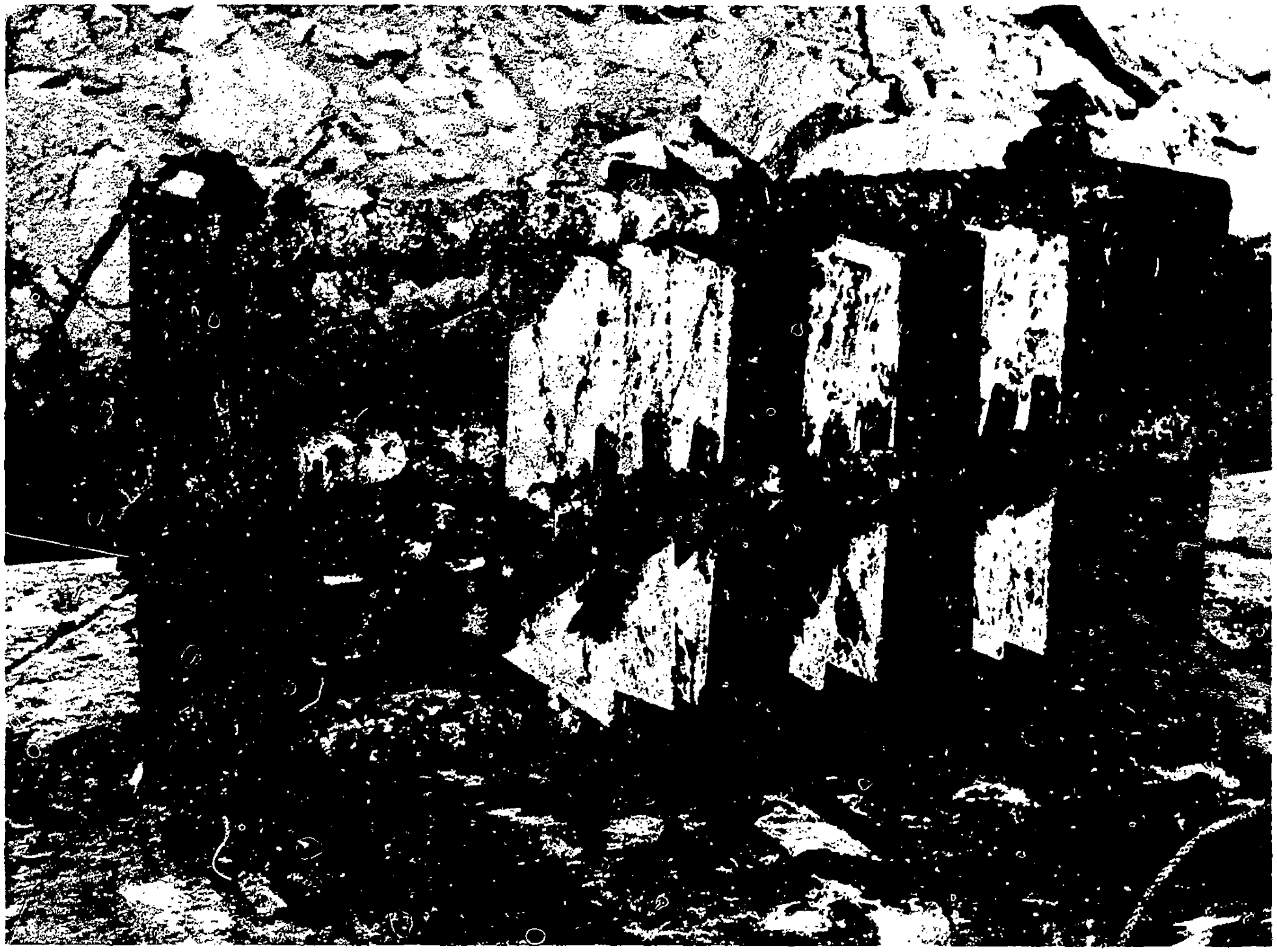

Figure 2. Rack showing panels after cleaning and ready to place in harbor for continued exposure.

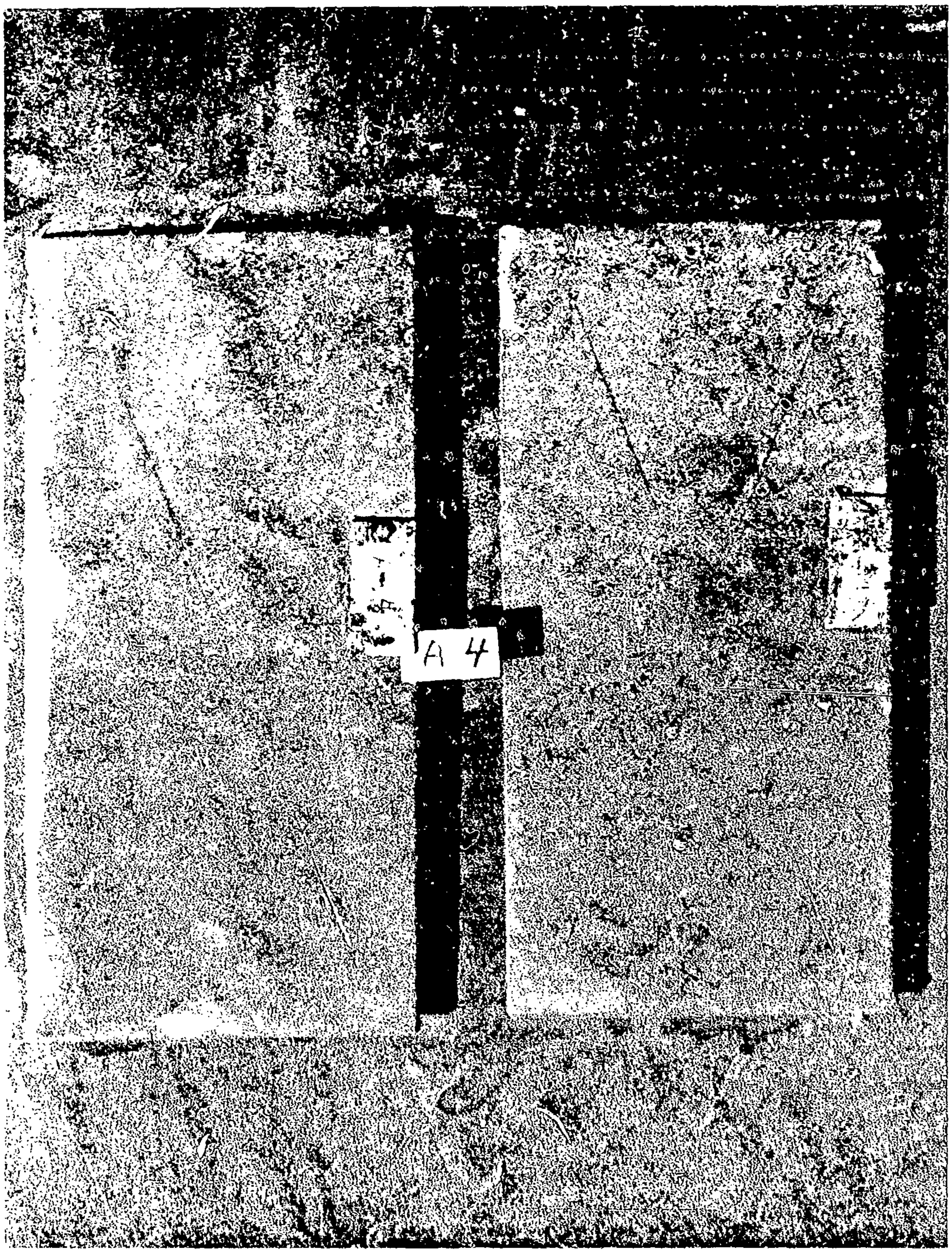

Figure 3. Self-curing zinc inorganic silicate, Rust Ban 191, (7.0 mils) after 3 years exposure in Port Hueneme Harbor.

Figure 4. Alodine 1200S anodized aluminum panel, pitted and corroded after 2 years in Port Hueneme Harbor.

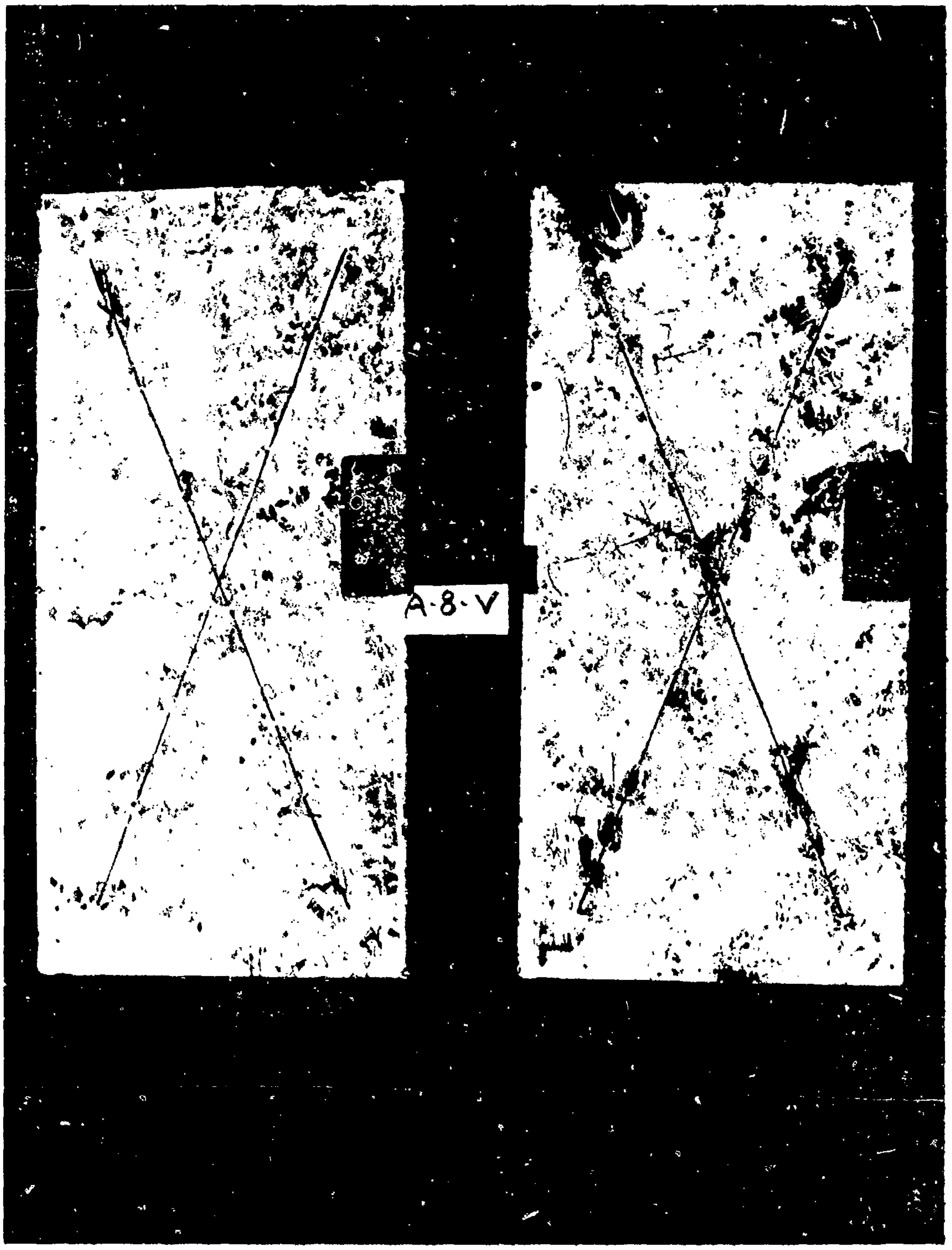

Figure 5. The specification vinyl system over Alodine 1200S after 3 years in Port Hueneme Harbor.

Figure 6. Plasite epoxy over Rust Ban 190 after 3 years in Port Hueneme Harbor.

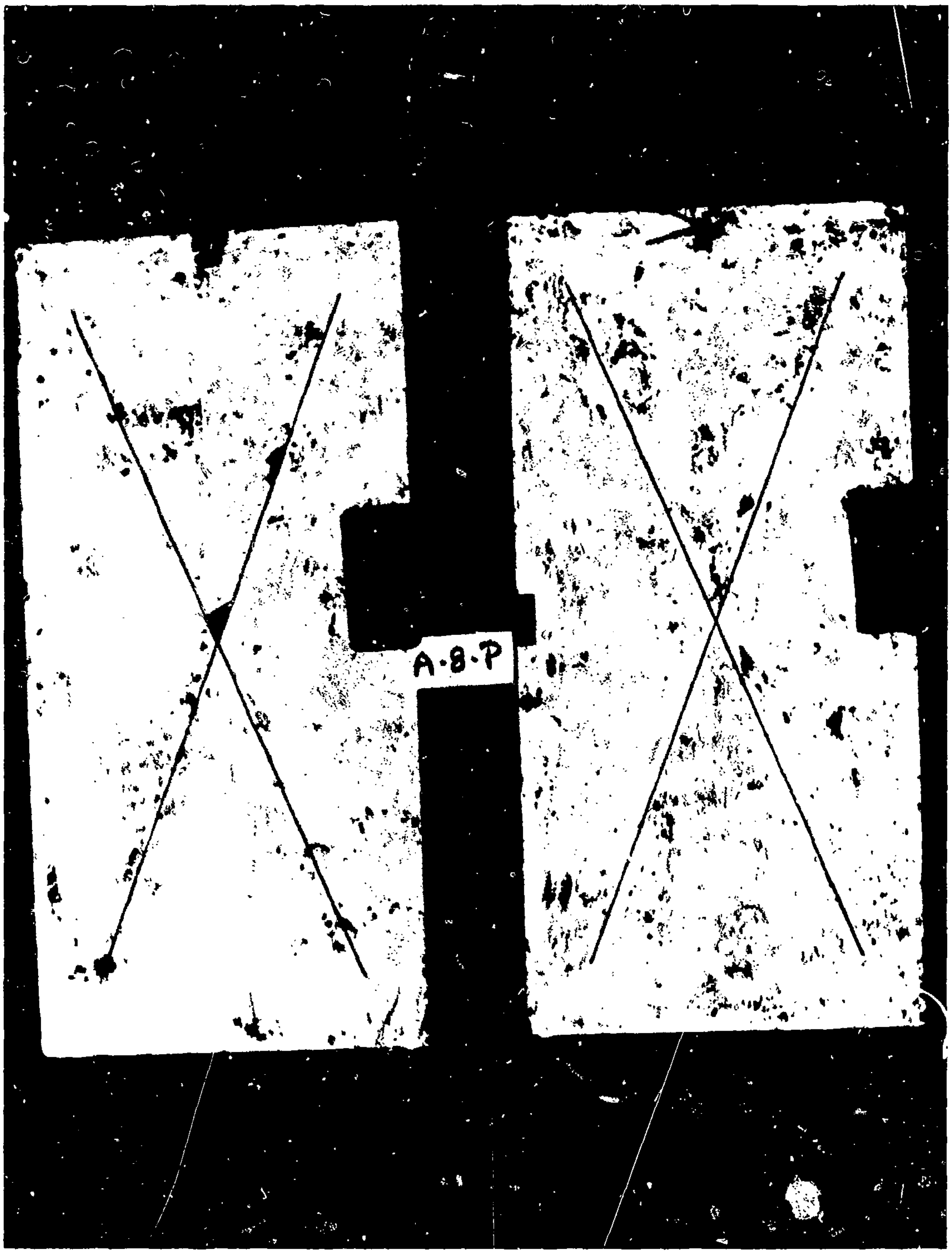

Figure 7. Plasite epoxy over Alodine 1200S, exposed 3 years in Port Hueneme Harbor.

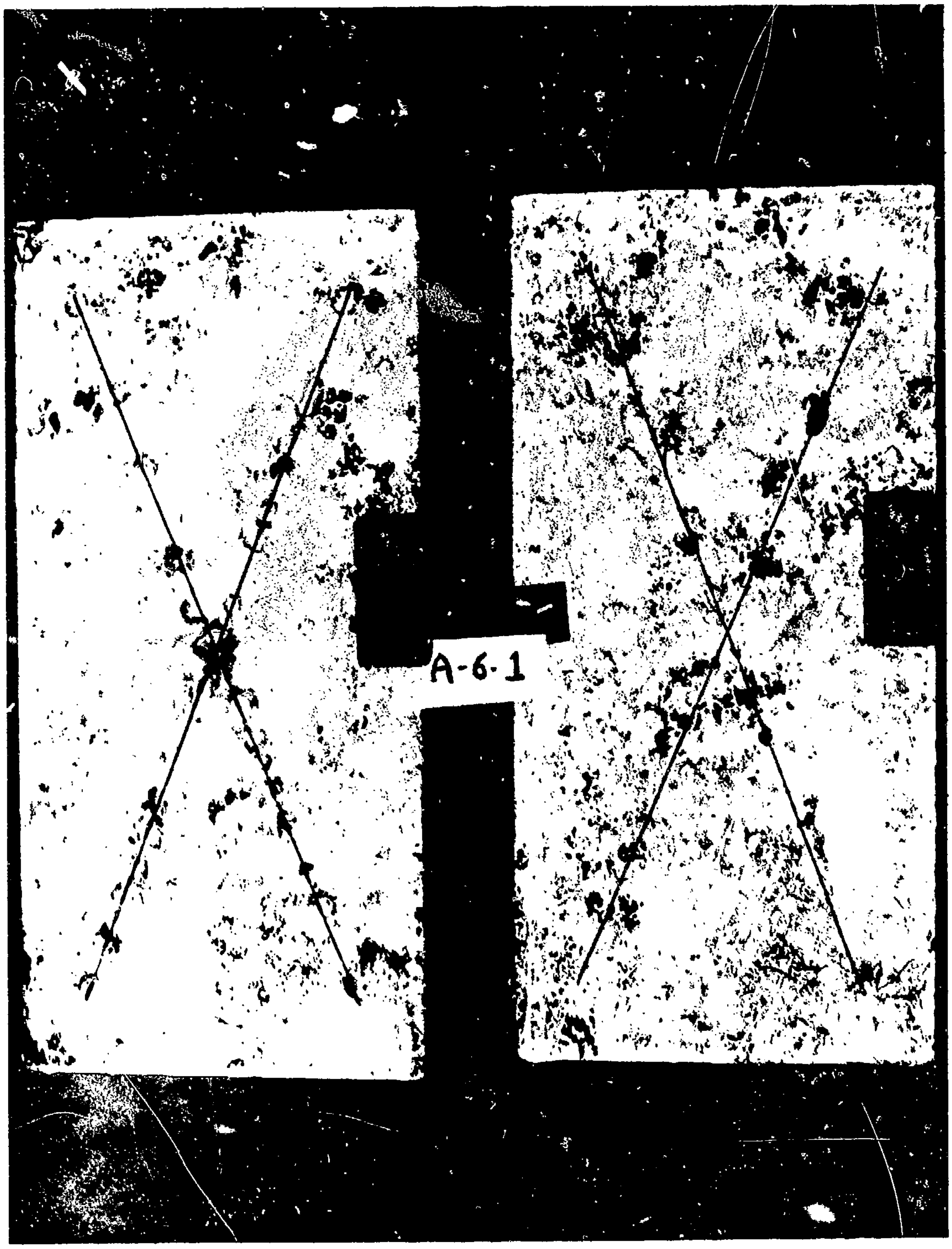

Figure 8. Zinc rich epoxy primer EX6662 and epoxy tcpcoat after 3 years in Port H'ueneme Harbor.

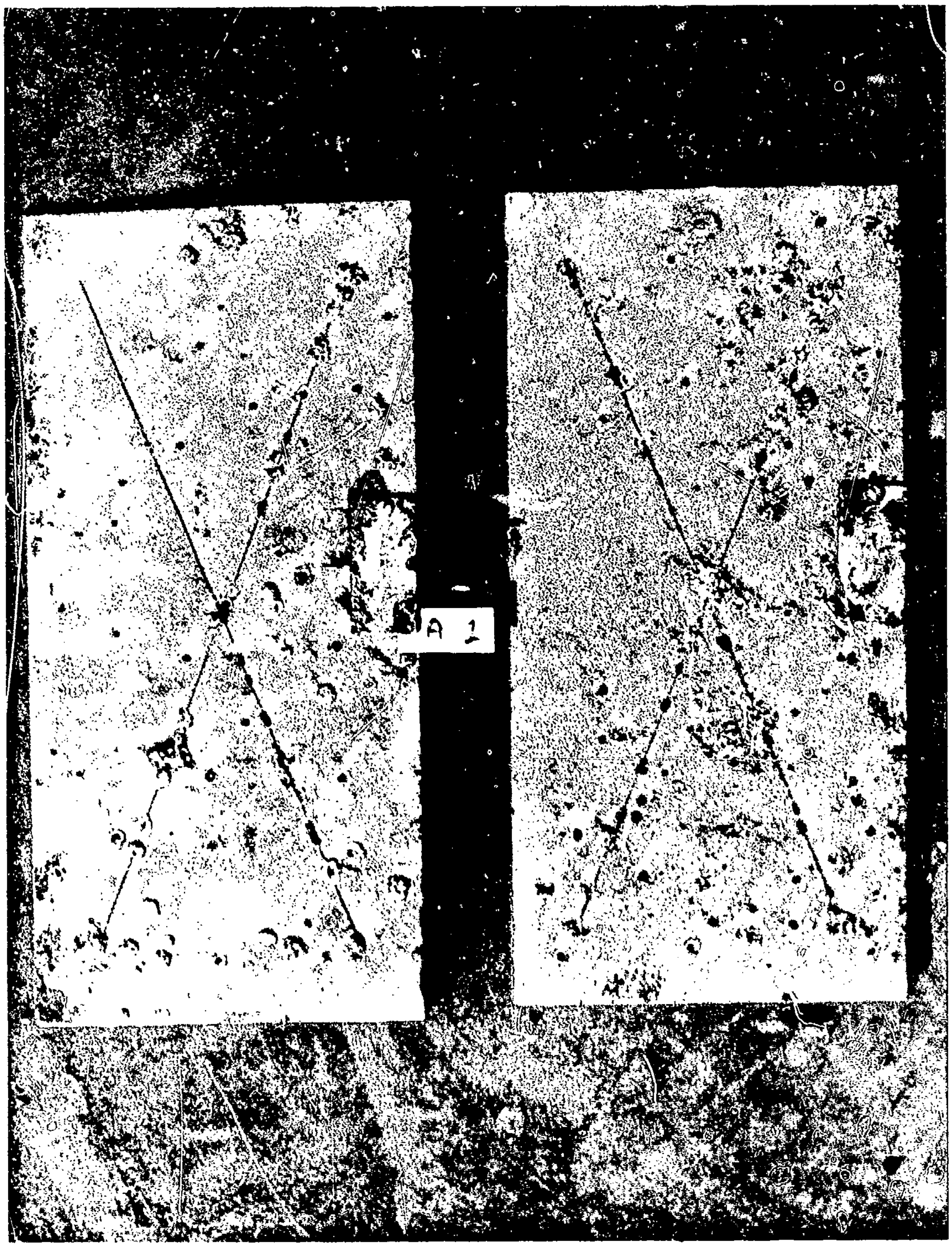

Figure 9. General blistering of the epoxy topcoat over Carbo Zinc 11 during 3 years in Port Hueneme Harbor.

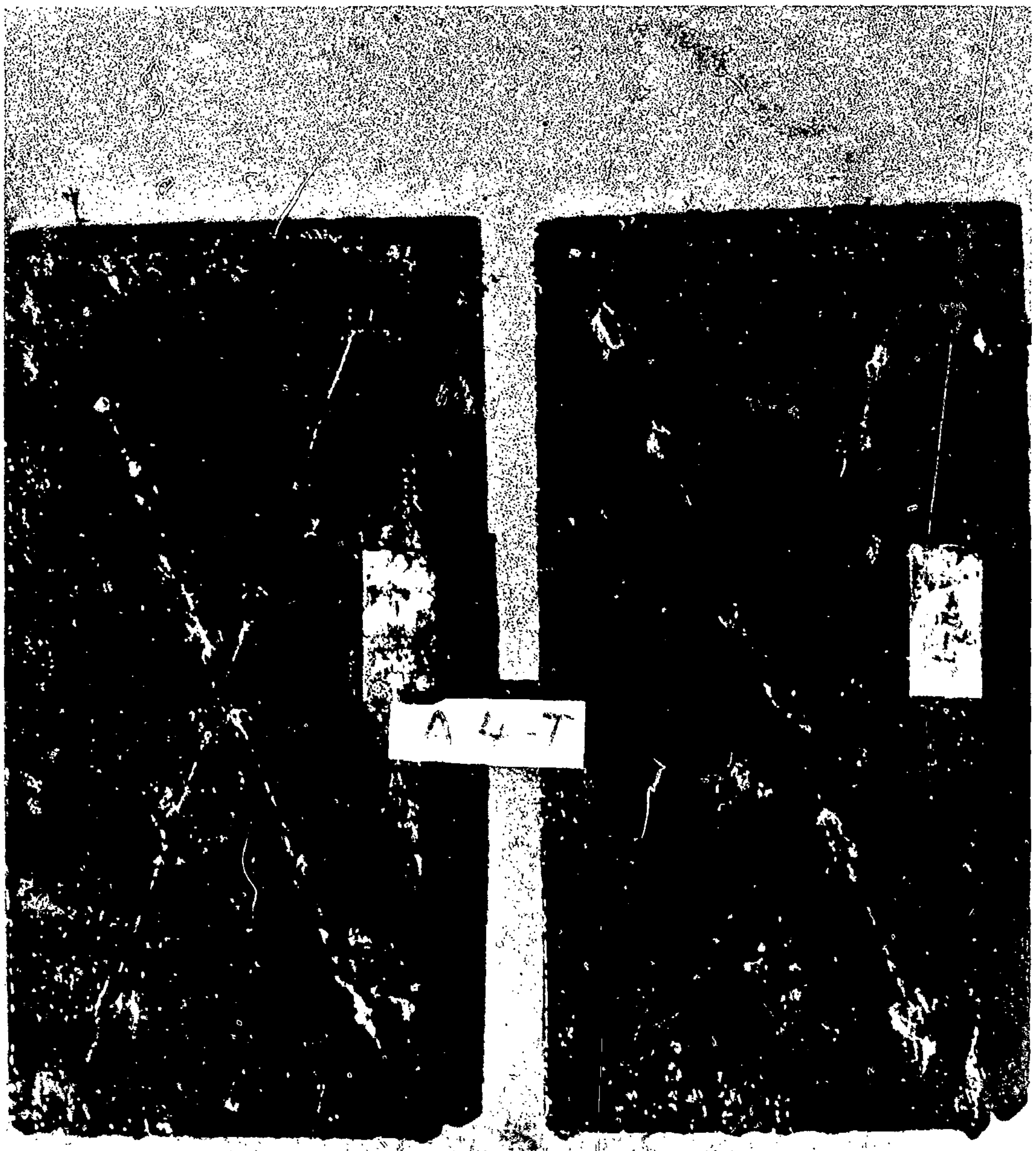

Figure 10. Coal Tar Epoxy over a zinc inorganic silicate (Rust Ban 191) after 3 years in Port Hueneme Harbor.

Figure 11. Coal Tar Epoxy over a zinc rich epoxy, Epolux E-14, showing loss of adhesion to the primer after 3 years exposure.

Appendix A

COATING SYSTEMS

System			No. of Coats		Thickness (mils)
A-1	Zinc Inorganic				
	Zinc inorganic silicate (SC)*		2		6.0
				Total	6.0
A-1-E	Epoxy (catalyzed)				
	Zinc inorganic silicate (SC)		1		3.0
	Epoxy (amide cured)	finish	2		7.0
				Total	10.0
A-1-V	Vinyl Alkyd				
	Zinc inorganic silicate		1		3.0
	Polyvinyl butyral resin pretreatment	primer	1		0.5
	Vinyl red lead	primer	2		3.0
	Vinyl alkyd	finish	2		4.0
				Total	10.5
A-1-T	Coal Tar Epoxy (catalyzed)				
	Zinc inorganic silicate (SC)		1		3.0
	Coal tar epoxy (amide cured)	finish	2		16.5
				Total	19.5
A-1-P	Epoxy Phenolic (catalyzed)				
	Zinc inorganic silicate (SC)		1		3.0
	Epoxy (amine cured)	primer	1		3.0
	Epoxy phenolic (amine cured)	finish	2		4.5
				Total	10.5
A-2	Zinc Inorganic				
	Zinc inorganic silicate (PC)**		2		6.5
				Total	6.5
A-2-E	Epoxy (catalyzed)				
	Zinc inorganic silicate (PC)		1		3.5
	Epoxy (amine cured)	primer	1		3.0
	Epoxy (amide cured)	finish	2		5.0
				Total	11.5

* SC - self-cured
**PC - postcured

System		No. of Coats			Thickness (mils)
A-2-V	Vinyl Alkyd				
	Zinc inorganic silicate (PC)		1		3.5
	Polyvinyl butyral resin, pretreatment	primer	1		0.5
	Vinyl red lead	primer	2		3.0
	Vinyl alkyd	finish	2		4.0
				Total	11.0
A-2-T	Coal Tar Epoxy (catalyzed)				
	Zinc inorganic silicate (PC)		1		3.5
	Coal tar epoxy (amide cured)	finish	2		16.5
				Total	20.0
A-2-P	Epoxy Phenolic (catalyzed)				
	Zinc inorganic silicate (PC)				3.5
	Epoxy (amine cured)	primer	1		3.0
	Epoxy phenolic (amine cured)	finish	2		4.5
				Total	11.0
A-3	Zinc Inorganic				
	Zinc inorganic silicate (PC)		1		3.0
				Total	3.0
A-3-E	Epoxy (catalyzed)				
	Zinc inorganic silicate (PC)		1		3.0
	Oxide red epoxy mastic (amide cured)	primer	1		4.0
	Epoxy (amide cured)	finish	2		5.0
				Total	12.0
A-3-V	Vinyl Alkyd				
	Zinc inorganic silicate (PC)		1		3.0
	Polyvinyl butyral resin, pretreatment	primer	1		0.5
	Vinyl red lead	primer	2		3.0
	Vinyl alkyd	finish	2		4.0
				Total	10.5
A-3-T	Coal Tar Epoxy (catalyzed)				
	Zinc inorganic silicate (PC)		1		3.0
	Coal Tar epoxy (amide cured)	finish	2		16.5
				Total	19.5

System			No. of Coats	Thickness (mils)
A-3-P	Epoxy Phenolic (catalyzed)			
	Zinc inorganic silicate (PC)		1	3.0
	Epoxy (amine cured)	primer	1	3.0
	Epoxy phenolic (amine cured)	finish	2	4.5
			Total	10.5
A-4	Zinc Inorganic			
	Zinc inorganic silicate (SC)		2	7.0
			Total	7.0
A-4-E	Epoxy (catalyzed)			
	Zinc inorganic silicate (SC)		1	3.0
	Oxide red epoxy mastic (amide cured)	primer	1	4.0
	Epoxy (amide cured)	finish	2	5.0
			Total	12.0
A-4-V	Vinyl Alkyd			
	Zinc inorganic silicate (SC)		1	3.0
	Polyvinyl butyral resin, pretreatment	primer	1	0.5
	Vinyl red lead	primer	2	3.0
	Vinyl alkyd	finish	2	4.0
			Total	10.5
A-4-T	Coal Tar Epoxy (catalyzed)			
	Zinc inorganic silicate (SC)		1	3.0
	Coal tar epoxy (amide cured)		2	16.5
			Total	19.5
A-4-P	Epoxy Phenolic (catalyzed)			
	Zinc inorganic silicate (SC)		1	3.0
	Epoxy (amine cured)	primer	1	3.0
	Epoxy phenolic (amine cured)	finish	2	4.5
			Total	10.5
A-5	Modified Saran			
	Modified Saran		4	6.0
			Total	6.0
A-5-S	Modified Saran			
	Modified Saran / zinc powder		2	3.0
	Modified Saran		6	6.0
			Total	9.0

System			No. of Coats		Thickness (mils)
A-6	Organic Zinc				
	Epoxy organic zinc (amide cured)		2		5.5
				Total	5.5
A-6-E	Epoxy (catalyzed)				
	Epoxy organic zinc (amide cured)		1		3.0
	Oxide red epoxy mastic (amide cured)	primer	1		4.0
	Epoxy (amide cured)	finish	2		5.0
				Total	12.0
A-6-T	Coal Tar Epoxy (catalyzed)				
	Epoxy organic zinc (amide cured)		1		3.0
	Coal tar epoxy (amide cured)	finish	2		16.5
				Total	19.5
A-6-P	Epoxy Phenolic (catalyzed)				
	Epoxy organic zinc (amide cured)		1		3.0
	Epoxy (amine cured)	primer	1		3.0
	Epoxy (amine cured)	finish	2		4.5
				Total	10.5
A-7	Organic Zinc (catalyzed)				
	Epoxy organic zinc (amide cured)		2		8.0
				Total	8.0
A-7-E	Epoxy (catalyzed)				
	Epoxy organic zinc (amide cured)		1		4.0
	Epoxy (amide cured)	finish	2		4.0
				Total	8.0
A-7-T	Coal Tar Epoxy (catalyzed)				
	Epoxy organic zinc (amide cured)		1		4.0
	Coal Tar epoxy (amide cured)		2		16.5
				Total	20.5
A-7-P	Epoxy Phenolic (catalyzed)				
	Epoxy organic zinc (amide cured)		1		4.0
	Epoxy (amine cured)	primer	1		3.0
	Epoxy phenolic (amine cured)	finish	2		4.0
				Total	11.0

System			No. of Coats		Thickness (mils)
A-8	Anodic Chemical Conversion Coating		1		----
A-8-E	Epoxy (catalyzed)				
	Anodic chemical conversion coating		1		----
	Oxide red epoxy mastic (Amide cured)	primer	1		4.0
	Epoxy (amide cured)	finish	2		5.0
				Total	9.0
A-8-V	Vinyl Alkyd				
	Anodic chemical conversion coating		1		----
	Polyvinyl butyral resin, pretreatment primer		1		0.5
	Vinyl zinc chromate	primer	3		5.0
	Vinyl alkyd	finish	2		4.0
				Total	9.5
A-8-T	Coal tar epoxy (catalyzed)				
	Anodic chemical conversion coating		1		----
	Coal tar epoxy (amide cured)	finish	2		16.5
				Total	16.5
A-8-P	Epoxy Phenolic (catalyzed)				
	Anodic chemical conversion coating		1		----
	Epoxy (amine cured)	primer	1		3.0
	Epoxy phenolic (amine cured)	finish	2		4.5
				Total	7.5
A-9-E	Epoxy (catalyzed)				
	Oxide red epoxy mastic (amide cured)	primer	1		4.0
	Epoxy (amide cured)	finish	2		5.0
				Total	9.0
A-9-V	Vinyl Alkyd				
	Polyvinyl butyral resin, Pretreatment	primer	1		0.5
	Vinyl zinc chromate	primer	3		5.0
	Vinyl alkyd	finish	2		4.0
				Total	9.5

System			No. of Coats		Thickness (mils)
A-9-T	Coal Tar Epoxy (catalyzed)				
	Coal tar epoxy (amide cured)	finish	2		16.5
				Total	16.5
A-9-P	Epoxy Phenolic (catalyzed)				
	Epoxy (amine cured)	primer	1		3.0
	Epoxy phenolic (amine cured)	finish	2		4.5
				Total	7.5
A-10-V	Vinyl Alkyd				
	Polyvinyl butyral resin, pretreatment primer		1		0.5
	Vinyl zinc chromate	primer	3		5.0
	Vinyl alkyd	finish	2		4.0
				Total	9.5
A-10-T	Coal tar epoxy (catalyzed)				
	Coal tar epoxy (amide cured)	finish	2		16.5
				Total	16.5
A-10-P	Epoxy Phenolic (catalyzed)				
	Epoxy (amine cured)	primer	1		3.0
	Epoxy phenolic (amine cured)	finish	2		4.5
				Total	7.5
A-11	Chlorinated Rubber				
	Zinc rich chlorinated rubber	finish	2		5.5
				Total	5.5
A-11-E	Epoxy (catalyzed)				
	Zinc rich chlorinated rubber		1		3.0
	Oxide red epoxy mastic (amide cured)	primer	1		4.0
	Epoxy (amide cured)	finish	2		5.0
				Total	12.0
A-11-T	Coal tar epoxy (catalyzed)				
	Zinc rich chlorinated rubber		1		3.0
	Coal tar epoxy (amide cured)		2		16.5
				Total	19.5

Appendix B

COATINGS SOURCES

System	Coating	Source
A-1	Carbo Zinc 11	Carboline Company 328 Hanley Industrial Ct. St. Louis, MO 63144
A-1-E	Carbo Zinc 11 Carboline HB190	Carboline Company 328 Hanley Industrial Ct. St. Louis, MO 63144
A-1-V	Carbo Zinc 11	Carboline Company 328 Hanley Industrial Ct. St. Louis, MO 63144
	MIL-P-15328B MIL-P-15929B	San Diego Coatings Company 2646 Main Street San Diego, CA 92113
	MIL-E-16738B	San Francisco Bay Naval Shipyard Mare Island Paint Laboratory Vallejo, CA 94592
A-1-T	Carbo Zinc 11	Carboline Company 328 Hanley Industrial Ct. St. Louis, MO 63144
	C-200	Pittsburgh Chemical Company Div. of U. S. Steel Corporation Grant Building Pittsburgh, PA 15219
A-1-P	Carbo Zinc 11	Carboline Company 328 Hanley Industrial Ct. St. Louis, MO 63144
	Plasite 7103 Plasite 7122	Wisconsin Protective Coating Corp. 614 Elizabeth Street, P.O. Box 243 Green Bay, WI 54305
A-2	Dimetcote 3	Amercoat Corporation 201 Berry Street Brea, CA 92621

System	Coating	Source
A-2-E	Dimetcote 3 Amercoat 64 Amercoat 66	Amercoat Corporation 201 No. Berry Street Brea, CA 92621
A-2-V	Dimetcote 3	Amercoat Corporation 201 No. Berry Street Brea, CA 92621
	MIL-P-15328B MIL-P-15929B	San Diego Coating Company 2646 Main Street San Diego, CA 92113
	MIL-E-16738B	San Francisco Bay Naval Shipyard Mare Island Paint Laboratory Vallejo, CA 94592
A-2-T	Dimetcote 3	Amercoat Corporation 201 No. Berry Street Brea, CA 92621
	C-200	Pittsburgh Chemical Company Div. of U. S. Steel Corporation Grant Building Pittsburgh, PA 15219
A-2-P	Dimetcote 3	Amercoat Corporation 201 No. Berry Street Brea, CA 92621
	Plasite 7103 Plasite 7122	Wisconsin Protective Coating Corp. 614 Elizabeth Street, P.O. Box 243 Green Bay, WI 54305
A-3	Rust Ban 190/195	Enjay Chemical Company 8230 Stedman Street Houston, TX 77029
A-3-E	Rust Ban 190/195 Rust Ban EM6664 Rust Ban EX6670	Enjay Chemical Company 8230 Stedman Street Houston, TX 77029
A-3-V	Rust Ban 190/195	Enjay Chemical Company 8230 Stedman Street Houston, TX 77029
	MIL-P-15328B MIL-P-15929B	San Diego Coatings Company 2646 Main Street San Diego, CA 92113

System	Coating	Source
	MIL-E-16738B	San Francisco Bay Naval Shipyard Mare Island Paint Laboratory Vallejo, CA 94592
A-3-T	Rust Ban 190/195	Enjay Chemical Company 8230 Stedman Street Houston, TX 77029
	C-200	Pittsburgh Chemical Company Div. of U. S. Steel Corporation Grant Building Pittsburgh, PA 15219
A-3-P	Rust Ban 190/195	Enjay Chemical Company 8230 Stedman Street Houston, TX 77029
	Plasite 7103 Plasite 7122	Wisconsin Protective Coating Corp. 614 Elizabeth Street, P.O. Box 243 Green Bay, WI 54305
A-4	Rust Ban 191 Rust Ban EM6664 Rust Ban EX6670	Enjay Chemical Company 8230 Stedman Street Houston, TX 77029
A-4-V	Rust Ban 191	Enjay Chemical Company 8230 Stedman Street Houston, TX 77029
	MIL-P-15328B MIL-P-15929B	San Diego Coatings Company 2646 Main Street San Diego, CA 92113
	MIL-E-16738B	San Francisco Bay Naval Shipyard Mare Island Paint Laboratory Vallejo, CA 94592
A-4-T	Rust Ban 191	Enjay Chemical Company 8230 Stedman Street Houston, TX 77029
	C-200	Pittsburgh Chemical Company Div. of U. S. Steel Corporation Grant Building Pittsburgh, PA 15219

System	Coating	Source
A-4-P	Rust Ban 191	Enjay Chemical Company 8230 Stedman Street Houston, TX 77029
	Plasite 7103 Plasite 7122	Wisconsin Protective Coating Corp. 614 Elizabeth Street, P.O. Box 243 Green Bay, WI 54305
A-5	Saran 3F-116-1	San Francisco Bay Naval Shipyard Mare Island Paint Laboratory Vallejo, CA 94592
	NJZ Zinc Dust 444	New Jersey Zinc Company 4560 East 50th Street Los Angeles, CA 90058
A-5-S	Saran 3F-116-1	San Francisco Bay Naval Shipyard Mare Island Paint Laboratory Vallejo, CA 94592
	NJZ Zinc Dust 444	New Jersey Zinc Company 4560 East 50th Street Los Angeles, CA 90058
	Saran 3F-116-4	San Francisco Bay Naval Shipyard Mare Island Paint Laboratory Vallejo, CA 94592
A-6	Rust Ban EX6662	Enjay Chemical Company 8230 Stedman Street Houston, TX 77029
A-6-E	Rust Ban EX6662 Rust Ban EM6664 Rust Ban EX6670	Enjay Chemical Company 8230 Stedman Street Houston, TX 77029
A-6-T	Rust Ban EX6662	Enjay Chemical Company 8230 Stedman Street Houston, TX 77029
	C-200	Pittsburgh Chemical Company Div. of U. S. Steel Corporation Grant Building Pittsburgh, PA 15219

System	Coating	Source
A-6-P	Rust Ban EX6662	Enjay Chemical Company 8230 Stedman Street Houston, Texas 77029
	Plasite 7103 Plasite 7122	Wisconsin Protective Coating Corp. 614 Elizabeth Street P.O. Box 243 Green Bay, Wis. 54305
A-7	Epo Lux E-14	Steelcote Manufacturing Company 3418 Gratiot Street St. Louis, Missouri 63103
A-7-E	Epo Lux E-14 Epo Lux E-1	Steelcote Manufacturing Company 3418 Gratiot Street St. Louis, Missouri 63103
A-7-T	Epo Lux E-14	Steelcote Manufacturing Company 3418 Gratiot Street St. Louis, Missouri 63103
	C-200	Pittsburgh Chemical Company Div. of U.S. Steel Corporation Grant Building Pittsburgh, PA. 15219
A-7-P	Epo Lux E-14	Steelcote Manufacturing Company 3418 Gratiot Street St. Louis Missouri 63103
	Plasite 7103 Plasite 7122	Wisconsin Protective Coating Corp. 614 Elizabeth Street P.O. Box 243 Green Bay, Wis. 54305
A-8	Alodine 1200S	Amchem Products Incorporated P.O. Box 2698 37899 Niles Boulevard Fremont, Calif. 94536
A-8 [illegible]	Alodine 1200S	Amchem Products Incorporated P.O. Box 2698 37899 Niles Boulevard Fremont, Calif. 94536
	Rust Ban EM6664 Rust Ban EX6670	Enjay Chemical Company 8230 Stedman Street Houston, Texas 77029

System	Coating	Source
A-8-V	Alodine 1200S	Amchem Products, Incorporated P.O. Box 2698 27899 Niles Boulevard Fremont, CA 94536
	MIL-P-15328B MIL-P-15930B	San Diego Coatings Company 2646 Main Street San Diego, CA 92113
	MIL-E-16738B	San Francisco Bay Naval Shipyard Mare Island Paint Laboratory Vallejo, CA 94592
A-8-T	Alodine 1200S	Amchem Products, Incorporated P.O. Box 2698 27899 Niles Boulevard Fremont, CA 94536
	C-200	Pittsburgh Chemical Company Div. of U. S. Steel Corporation Grant Building Pittsburgh, PA 15219
A-8-P	Alodine 1200S	Amchem Products, Incorporated P.O. Box 2698 27899 Niles Boulevard Fremont, CA 94536
	Plasite 7103 Plasite 7122	Wisconsin Protective Coating Corp. 614 Elizabeth Street, P.O. Box 243 Green Bay, WI 54305
A-9-V	MIL-P-15328B MIL-P-15930B	San Diego Coatings Company 2646 Main Street San Diego, CA 92113
	MIL-E-16738B	San Francisco Bay Naval Shipyard Mare Island Paint Laboratory Vallejo, CA 94592
A-9-T	C-200	Pittsburgh Chemical Company Div. of U. S. Steel Corporation Grant Building Pittsburgh, PA 15219
A-9-P	Plasite 7103 Plasite 7122	Wisconsin Protective Coating Corp. 614 Elizabeth Street, P.O. Box 243 Green Bay, WI 54305

System	Coating	Source
A-10-V	MIL-P-15328B MIL-P-15930B	San Diego Coatings Company 2646 Main Street San Diego, CA 92113
	MIL-E-16738B	San Francisco Bay Naval Shipyard Mare Island Paint Laboratory Vallejo, CA 94592
A-10-T	C-200	Pittsburgh Chemical Company Div. of U. S. Steel Corporation Grant Building Pittsburgh, PA 15219
A-10-P	Plasite 7103 Plasite 7122	Wisconsin Protective Coating Corp. 614 Elizabeth Street, P.O. Box 243 Green Bay, WI 54305
A-11	Rust Ban CR6875	Enjay Chemical Company 8230 Stedman Street Houston, TX 77029
A-11-E	Rust Ban CR6875 Rust Ban EM6664 Rust Ban EX6670	Enjay Chemical Company 8230 Stedman Street Houston, TX 77029
A-11-T	Rust Ban CR6875	Enjay Chemical Company 8230 Stedman Street Houston, TX 77029
	C-200	Pittsburgh Chemical Company Div. of U. S. Steel Corporation Grant Building Pittsburgh, PA 15219

Appendix C

COATINGS ANALYSES

System Coating	Wt./gal. (lbs)	Specific Gravity (g/ml)	Consistency (Kreb Units)	Non Vol. Solids (%)	Pigment (%)	Non Vol. Vehicle (%)
A-1 Zinc Inorganic						
Zinc inorganic silicate (liquid)	9.02	-	Too thin	30.10	-	30.10
Zinc Powder	-	-	-	-	-	-
A-1-E Epoxy (catalyzed)						
Zinc inorganic silicate (liquid)	9.02	-	Too thin	30.10	-	30.10
Zinc Powder	-	-	-	-	-	-
Epoxy (Comp. A)	12.66	-	92	78.20	42.13	36.07
(Comp. B)	11.19	-	72	70.53	43.35	27.18
A-1-V Vinyl Alkyd						
Zinc inorganic silicate (liquid)	9.02	-	Too thin	30.10	-	30.10
Zinc Powder	-	-	-	-	-	-
Polyvinyl butyral resin			Meets Spec.			
Vinyl red lead			Meets Spec.			
Vinyl alkyd			Meets Spec.			
A-1-T Epoxy Tar (catalyzed)						
Zinc inorganic silicate (liquid)	9.02	-	Too thin	30.10	-	30.10
Zinc Powder	-	-	-	-	-	-
Coal tar epoxy	Too thick	-	-	80.03	47.45	32.58
Activator	-	-	-	-	-	-
A-1-P Epoxy Phenolic (catalyzed)						
Zinc inorganic silicate (liquid)	9.02	-	Too thin	30.10	-	30.10
Zinc Powder	-	-	-	-	-	-
Epoxy mastic	12.35	1.482	66	68.07	48.23	19.84
Amine activator	-	-	-	-	-	-
Epoxy phenolic	10.81	1.297	60	69.59	35.59	34.00
Activator	-	-	-	-	-	-
A-2 Zinc Inorganic						
Zinc inorganic silicate (liquid)	10.70	1.284	50	35.10	-	35.10

System / Coating	Wt./gal. (lbs)	Specific Gravity (g/ml)	Consistency (Kreb Units)	Non Vol. Solids (%)	Pigment (%)	Non Vol. Vehicle (%)
A-2-E Epoxy (catalyzed)						
Zinc inorganic silicate (liquid)	10.70	1.284	50	35.10	-	35.10
Zinc powder	-	-	-	-	-	-
Epoxy	9.29	-	-	48.25	29.21	19.04
Activator	-	-	-	27.89	-	27.89
Epoxy	12.05	-	94	72.29	48.48	23.81
Activator	10.57	-	100	72.40	-	72.40
A-2-V Vinyl Alkyd						
Zinc inorganic silicate (liquid)	10.70	1.284	50	35.10	-	35.10
Zinc powder	-	-	-	-	-	-
Polyvinyl butyral resin			Meets Spec.			
Vinyl red lead			Meets Spec.			
Vinyl alkyd			Meets Spec.			
A-2-T Epoxy Tar (catalyzed)						
Zinc inorganic silicate (liquid)	10.70	1.284	50	35.10	-	35.10
Zinc powder	-	-	-	-	-	-
Coal tar epoxy	Too Thick	-	-	80.03	47.45	32.58
Activator	-	-	-	-	-	-
A-2-P Epoxy Phenolic (catalyzed)						
Zinc inorganic silicate (liquid)	10.70	1.284	50	35.10	-	35.10
Zinc powder	-	-	-	-	-	-
Epoxy mastic	12.35	1.482	66	68.07	48.23	19.84
Activator	-	-	-	-	-	-
Epoxy phenolic	10.81	1.297	60	69.59	35.59	34.00
Activator	-	-	-	-	-	-
A-3 Zinc Inorganic						
Zinc inorganic silicate (liquid)	10.95	-	51	38.84	-	38.84
Zinc powder	-	-	-	-	-	-

System	Coating	Wt./gal. (lbs)	Specific Gravity (g/ml)	Consistency (Kreb Units)	Non Vol. Solids (%)	Pigment (%)	Non Vol. Vehicle (%)
A-3-E	Epoxy						
	Zinc inorganic silicate (liquid)	10.95	-	51	38.84	-	38.84
	Zinc powder	-	-	-	-	-	-
	Oxide red epoxy mastic	13.24	-	101	75.73	53.20	22.53
	Activator	-	-	-	-	-	-
	Epoxy	11.18	-	61	62.27	36.63	25.64
	Activator	-	-	-	-	-	-
A-3-V	Vinyl Alkyd						
	Zinc inorganic silicate (liquid)	10.95	-	51	38.84	-	38.84
	Zinc powder	-	-	-	-	-	-
	Polyvinyl butyral resin			Meets Spec.			
	Vinyl red lead			Meets Spec.			
	Vinyl Alkyd			Meets Spec.			
A-3-T	Epoxy Tar (catalyzed)						
	Zinc inorganic silicate (liquid)	10.95	-	51	38.84	-	38.84
	Zinc powder	-	-	-	-	-	-
	Coal tar epoxy	Too Thick	-	-	80.03	47.05	32.58
	Activator	-	-	-	-	-	-
A-3-P	Epoxy Phenolic (catalyzed)						
	Zinc inorganic silicate (liquid)	10.95	-	51	38.84	-	38.84
	Zinc powder	-	-	-	-	-	-
	Epoxy mastic	12.[illegible]5	1.482	66	68.07	48.23	19.84
	Activator	-	-	-	-	-	-
A-4	Zinc Inorganic (S.C.)						
	Zinc inorganic silicate (liquid)	9.94	1.192	47	26.30	-	26.30
	Zinc powder	-	-	-	-	-	-

System Coating	Wt./gal. (lbs)	Specific Gravity (g/ml)	Consistency (Kreb Units)	Non Vol. Solids (%)	Pigment (%)	Non Vol. Vehicle (%)
A-4-E Epoxy (catalyzed)						
Zinc inorganic silicate (liquid)	9.94	1.192	47	26.30	-	26.30
Zinc powder	-	-	-	-	-	-
Oxide red epoxy mastic	13.24	-	101	75.73	53.20	22.53
Activator	-	-	-	-	-	-
Epoxy	11.18	-	61	62.27	36.63	25.64
Activator	-	-	-	-	-	-
A-4-V Vinyl Alkyd						
Zinc inorganic silicate (liquid)	9.94	1.192	47	26.30	-	26.30
Zinc powder	-	-	-	-	-	-
Polyvinyl butyral resin			Meets Spec.			
Vinyl red lead			Meets Spec.			
Vinyl Alkyd			Meets Spec.			
A-4-T Epoxy Tar (catalyzed)						
Zinc inorganic silicate (liquid)	9.94	1.192	47	26.30	-	26.30
Zinc powder	-	-	-	-	-	-
Coal tar epoxy	Too thick	-	-	80.03	47.45	32.58
Activator	-	-	-	-	-	-
A-4-P Epoxy Phenolic (catalyzed)						
Zinc inorganic silicate (liquid)	9.94	1.192	47	26.30	-	26.30
Zinc powder	-	-	-	-	-	-
Epoxy mastic	12.35	1.482	66	68.07	48.23	19.84
Activator	-	-	-	-	-	-
Epoxy phenolic	10.81	1.297	60	69.59	35.59	34.00
Activator	-	-	-	-	-	-
A-5 Saran						
Modified saran	8.58	-	59	14.66	8.45	6.21
Zinc powder	-	-	-	-	-	-

System Coating	Wt./gal. (lbs)	Specific Gravity (g/ml)	Consistency (Kreb Units)	Non Vol. Solids (%)	Pigment (%)	Non Vol. Vehicle (%)
A-5-S Saran						
Modified saran	8.58	-	59	14.66	8.45	6.21
Zinc powder	-	-	-	-	-	-
Modified saran	8.50	-	59	13.21	6.34	6.87
A-6 Organic Zinc (catalyzed)						
Epoxy organic zinc (liquid)	8.36	-	53	51.09	-	51.09
Activator	-	-	-	-	-	-
Zinc powder	-	-	-	-	-	-
A-6-E Epoxy (catalyzed)						
Epoxy organic zinc (liquid)	8.36	-	53	51.09	-	51.09
Activator	-	-	-	-	-	-
Zinc powder	-	-	-	-	-	-
Oxide red epoxy mastic	13.24	-	101	75.73	53.20	22.53
Activator	-	-	-	-	-	-
Epoxy	11.13	-	61	62.27	36.63	25.64
Activator	-	-	-	-	-	-
A-6-T Epoxy Tar (catalyzed)						
Epoxy organic zinc (liquid)	8.36	-	53	51.09	-	51.09
Activator	-	-	-	-	-	-
Zinc powder	-	-	-	-	-	-
Coal tar epoxy	Too thick	-	-	80.03	47.45	32.58
Activator	-	-	-	-	-	-
A-6-P Epoxy Phenolic (catalyzed)						
Epoxy organic zinc (liquid)	8.36	-	53	51.09	-	51.09
Activator	-	-	-	-	-	-
Zinc powder	-	-	-	-	-	-
Epoxy mastic	12.35	1.482	66	68.07	48.23	19.84
Activator	-	-	-	-	-	-
Epoxy phenolic	10.81	1.297	60	69.59	35.59	34.00
Activator	-	-	-	-	-	-

System Coating	Wt./gal. (lbs)	Specific Gravity (g/ml)	Consistency (Kreb Units)	Non Vol. Solids (%)	Pigment (%)	Non Vol. Vehicle (%)
A-7 Organic Zinc						
Epoxy organic zinc (liquid)	7.71	-	<43	20.96	-	20.96
Activator	-	-	-	-	-	-
Zinc powder	-	-	-	-	-	-
A-7-E Epoxy (catalyzed)						
Epoxy organic zinc (liquid)	7.71	-	<43	20.96	-	20.96
Activator	-	-	-	-	-	-
Zinc powder	-	-	-	-	-	-
Epoxy	10.78	-	59	55.09	35.60	19.49
Activator	-	-	-	-	-	-
A-7-T Epoxy Tar (catalyzed)						
Epoxy organic zinc (liquid)	7.71	-	<43	20.96	-	20.96
Activator	-	-	-	-	-	-
Zinc powder	-	-	-	-	-	-
Coal tar epoxy	Too thick	-	-	80.03	47.45	32.58
Activator	-	-	-	-	-	-
A-7-P Epoxy Phenolic (catalyzed)						
Epoxy organic zinc (liquid)	7.71	-	<43	20.96	-	20.96
Activator	-	-	-	-	-	-
Zinc powder	-	-	-	-	-	-
Epoxy mastic	12.35	1.482	66	68.07	48.23	19.84
Activator	-	-	-	-	-	-
Epoxy phenolic	10.81	1.297	60	69.59	35.59	34.00
Activator	-	-	-	-	-	-
A-8 Anodic Conversion						
Anodic chemical film	-	-	-	-	-	-

System	Coating	Wt./gal. (lbs)	Specific Gravity (g/ml)	Consistency (Kreb Units)	Non Vol. Solids (%)	Pigment (%)	Non Vol. Vehicle (%)
A-8-E	Epoxy (catalyzed)						
	Anodic chemical film	-	-	-	-	-	-
	Oxide red epoxy mastic	13.24	-	101	75.73	53.20	22.53
	Activator	-	-	-	-	-	-
	Epoxy	11.18	-	61	62.27	36.63	25.64
	Activator	-	-	-	-	-	-
A-8-V	Vinyl Alkyd						
	Anodic chemical film	-	-	-	-	-	-
	Polyvinyl butyral resin			Meets Spec.			
	Vinyl zinc chromate			Meets Spec.			
	Vinyl alkyd			Meets Spec.			
A-8-T	Epoxy Tar (catalyzed)						
	Anodic chemical film	-	-	-	-	-	-
	Coal tar epoxy	Too thick	-	-	80.03	47.45	32.58
A-8-P	Epoxy Phenolic (catalyzed)						
	Anodic chemical film	-	-	-	-	-	-
	Epoxy mastic	12.35	1.482	66	68.07	48.23	19.84
	Activator	-	-	-	-	-	-
	Epoxy phenolic	10.81	1.297	60	69.59	35.59	34.00
	Activator	-	-	-	-	-	-
A-9-E	Epoxy (catalyzed)						
	Oxide red epoxy mastic	13.24	-	101	75.73	53.20	22.53
	Activator	-	-	-	-	-	-
	Epoxy	11.18	-	61	62.27	36.63	25.64
	Activator	-	-	-	-	-	-
A-9-V	Vinyl Alkyd						
	Polyvinyl butyral resin			Meets Spec.			
	Vinyl zinc chromate			Meets Spec.			
	Vinyl alkyd			Meets Spec.			

System Coating	Wt./gal. (lbs)	Specific Gravity (g/ml)	Consistency (Kreb Units)	Non Vol. Solids (%)	Pigment (%)	Non Vol. Vehicle (%)
A-9-T Epoxy Tar (catalyzed						
Coal tar epoxy	Too thick	-	-	80.03	47.45	32.58
A-9-P Epoxy Phenolic (catalyzed)						
Epoxy mastic	12.35	1.482	66	68.07	48.23	19.84
Activator	-	-	-	-	-	-
Epoxy phenolic	10.81	1.297	60	69.59	35.59	34.00
Activator	-	-	-	-	-	-
A-10-V Vinyl Alkyd						
Polyvinyl butyral resin			Meets Spec.			
Vinyl zinc chromate			Meets Spec.			
Vinyl alkyd			Meets Spec.			
A-10-T Epoxy Tar (catalyzed)						
Coal tar epoxy	Too thick	-	-	80.03	47.45	32.58
Activator	-	-	-	-	-	-
A-10-P Epoxy Phenolic (catalyzed)						
Epoxy mastic	12.35	1.482	66	68.07	48.23	19.84
Activator	-	-	-	-	-	-
Epoxy phenolic	10.81	1.297	60	69.59	35.59	34.00
A-11 Zinc Rich Coating						
Zinc rich chlorinated rubber (liquid)	8.62	-	55	33.61	6.83	26.78
Zinc powder	-	-	-	-	-	-
A-11-E Epoxy (catalyzed)						
Zinc rich chlorinated rubber (liquid)	8.62	-	55	33.61	6.83	26.78
Zinc powder	-	-	-	-	-	-
Oxide red epoxy mastic	13.24	-	101	75.73	53.20	22.53
Activator	-	-	-	-	-	-
Epoxy	11.18	-	61	62.27	33.63	25.64
Activator	-	-	-	-	-	-

System	Coating	Wt./gal. (lbs)	Specific Gravity (g/ml)	Consistency (Kreb Units)	Non Vol. Solids (%)	Pigment (%)	Non Vol. Vehicle (%)
A-11-T	Epoxy Tar (catalyzed)						
	Zinc rich chlorinated rubber (liquid)	8.62	-	55	33.61	6.83	26.78
	Zinc powder	-	-	-	-	-	-
	Coal tar epoxy	Too thick	-	-	80.03	47.45	32.58
	Activator	-	-	-	-	-	-

Appendix D

RATING OF COATING SYSTEM

The coatings were inspected, photographed, and rated after 2 and 3 years of exposure.

Ratings were assigned by NCEL personnel in accordance with ASTM standards, where applicable. A numerical rating system was used for recording the degree of protection given by a coating; a rating of 10 indicated complete protection, and a rating of 0 indicated no protection. For example, if the metal substrate had lost protection over 10 to 20 percent of its surface, the coating was given a rating of 8. For the purpose of this report, a protection rating of 7 indicated coating failure; this rating indicates that maintenance or recoating is necessary. A letter "E" in the tabulation indicates the rating relates to the edges and a letter "S" to the scribe.

The degree of appearance of corrosion of the aluminum was rated in accordance with ASTM Designation D610-43 for rusting. Both Type 1 "corrosion", without blistering and Type 2 "corrosion", with blistering were rated.

The blister size is also designated 10 to 2; 10 indicates no blisters, 8 indicates the smallest blister easily seen with the unaided eye, and 6, 4 and 2 represent progressively larger sizes. Size 2 represents a blister diameter of about 1/8-inch or over. The frequency of occurrence of blisters is reported as dense (D), medium dense (MD), medium (M), and few (F), where "dense" represents complete surface coverage, and "few" only occasional blistering. Thus a rating of 2/M would represent blisters of 1/8-inch diameter or over occurring over possibly one-third of the surface.

Letters were used to rate pitting and undercutting also. The letters VL indicates very light or negligible attack and "L" indicates light undercutting or occasional attack and "H" heavy or a significant attack. "M" or medium would be a degree between "L" and "H".

APPENDIX D

RATING OF COATING SYSTEMS

System	Years Exposed	Unscribed Surface						Scribed Surface			
		Protection	Blistering	Undercutting Edges	Rusting Type		Pitting	Blistering	Under-cutting	Protection	Corrosion
					I	II					
A-1	1										
	2	9+	10	10	10	10	L	10	10	9+	-
	3	9	10	10	10	10	M	10	10	9	-
A-1-E	1										
	2	9+	$4/F^{E}$	10	10	10	10	4/D	10	9	10
	3	8	$2/D^{E}$	10	10	10	-	4/D	L	7	L
A-1-V	1										
	2	10	10	10	10	10	10	2/F	10	10	10
	3	9	10	10	10	10	-	2/M	M	8	M
A-1-T	1										
	2	9+	10	10	10	10	10	2/M	10	9	-
	3	9	10	10	10	10	-	2/MD	M	8	L
A-1-P	1										
	2	9+	$4/F^{E}$	10	10	10	10	4/MD	10	9	-
	3	9	$4/M^{E}$	10	10	10	-	2/M	L	9	L
	1										
	2										
	3										

Remarks;

APPENDIX D

RATING OF COATING SYSTEMS

System	Years Exposed	Unscribed Surface: Protection	Unscribed Surface: Blistering	Unscribed Surface: Undercutting Edges	Unscribed Surface: Rusting Type I	Unscribed Surface: Rusting Type II	Unscribed Surface: Pitting	Scribed Surface: Blistering	Scribed Surface: Under-cutting	Scribed Surface: Protection	Scribed Surface: Corrosion
A-2	1										
	2	9+	10	10	10	10	10	10	10	9+	-
	3	8	10	10	10	10	H	10	10	7	H
A-2-E	1										
	2	9+	10	10	10	10	10	10	VL	9+	-
	3	9-		10	10	10	M	2/M	L	8	M
A-2-V	1										
	2	9+	10	10	10	10	10	4/F	VL	9+	10
	3	9	10	10	10	10	-	2/F	L	9	L
A-2-T	1										
	2	9+	10	10	10	10	10	2/F	VL	9+	10
	3	9+	10	10	10	10	10	2/F	L	9+	L
A-2-P	1										
	2	10	10	10	10	10	10	2/MD	10	9+	10
	3	9+	10	10	10	10	10	2/F	VL	9	L
	1										
	2										
	3										

Remarks;

APPENDIX D

RATING OF COATING SYSTEMS

System	Years Exposed	Unscribed Surface: Protection	Blistering	Undercutting Edges	Rusting Type I	Rusting Type II	Pitting	Scribed Surface: Blistering	Under-cutting	Protection	Corrosion
A-3	1										
	2	10	10	10	10	10	10	10	10	10	10
	3	8	10	10	10	10	M	10	10	8	H
A-3-E	1										
	2	10	10	10	10	10	10	2/F	10	10	10
	3	9+	10	10	10	10	10	2/F	L	9	L
A-3-V	1										
	2	10	10	10	10	10	-	-	10	10	10
	3	9+	10	10	10	10	-	2/F	L	9	M
A-3-T	1										
	2	9+	4/F	10	10	10	-	-	10	9+	10
	3	9	10	10	10	10	-	2/M	M	8	M
A-3-P	1										
	2	10	10	10	10	10	10	10	10	10	10
	3	10	10	10	10	10	-	2/F	10	9+	VL
	1										
	2										
	3										

Remarks;

APPENDIX D

RATING OF COATING SYSTEMS

System	Years Exposed	Unscribed Surface						Scribed Surface			
		Protection	Blistering	Undercutting Edges	Rusting Type I	Rusting Type II	Pitting	Blistering	Under-cutting	Protection	Corrosion
A-4	1										
	2	10	10	10	10	10	-	10	10	10	10
	3	10	10	10	10	10	-	10	10	10	10
A-4-E	1										
	2	10	10	9+	10	10	-	2/F	10	9	10
	3	10	10	-	10	10	-	2/F	L	9	M
A-4-V	1										
	2	10	10	10	10	10	-	10	10	10	10
	3	9+	4/F	10	10	10	-	2/M	L	9	10
A-4-T	1										
	2	10	10	10	10	10	-	2/F	VL	10	10
	3	9+	10	10	10	10	-	2/F	M	9	M
A-4-P	1										
	2	9	2/F	10	10	10	-	2/F	VL	9	10
	3	9	2/M	10	10	10	-	2/M	L	9	10
	1										
	2										
	3										

Remarks;

APPENDIX D

RATING OF COATING SYSTEMS

System	Years Exposed	Unscribed Surface						Scribed Surface			
		Protection	Blistering	Undercutting Edges	Rusting Type I	Rusting Type II	Pitting	Blistering	Under-cutting	Protection	Corrosion
A-5	1										
	2	9+	10	10	10	10	-	2/F	VL	9	10
	3	9	10	10	10	10	-	2/M	L	9	L
A-5-S	1										
	2	10	10	10	10	10	-	10	VL	9+	10
	3	10	10	10	10	10	-	2/M	L	9	L
A-6	1										
	2	10	10	10	10	10	-	10	10	10	10
	3	9	10	10	10	10	-	2/MD	L	8	M
A-6-E	1										
	2	10	10	10	10	10	-	2/F	VL	9+	10
	3	10	10	10	10	10	-	2/M	L	9	L
A-6-T	1										
	2	9+	10	10	10	10	-	2/F	VL	9+	10
	3	9	10	10	10	10	-	2/M	L	9	L
A-6-P	1										
	2	9+	10	10	10	10	-	2/F	VL	9+	10
	3	9	10	10	10	10	-	2/F	L	9	L

Remarks;

APPENDIX D

RATING OF COATING SYSTEMS

System	Years Exposed	Unscribed Surface: Protection	Unscribed Surface: Blistering	Unscribed Surface: Undercutting Edges	Unscribed Surface: Rusting Type I	Unscribed Surface: Rusting Type II	Unscribed Surface: Pitting	Scribed Surface: Blistering	Scribed Surface: Under-cutting	Scribed Surface: Protection	Scribed Surface: Corrosion
A-7	1										
	2	8	4/MD^E	9+	10	10	10	10	10	9	10
	3	8	4/D	8	10	10	M	2/M	H	8	L
A-7-E	1										
	2	9	10	10	10	10	-	2/F		9	VL
	3	9	10	10	10	10	-	2/D	H	6	L
A-7-T	1										
	2	4	2/D^S	10	10	10	H	2/D^E	H	5	M
	3	3	3*	-	-	-	-	-	-	3	-
A-7-P	1										
	2	9+	2/F	10	10	10	-	2/F	VL	9+	10
	3	9	10	10	10	10	-	2/F	L	9	L
	1										
	2										
	3										
	1										
	2										
	3										

Remarks; *General big blister and flaking.

APPENDIX D

RATING OF COATING SYSTEMS

System	Years Exposed	Unscribed Surface						Scribed Surface			
		Protection	Blistering	Undercutting Edges	Rusting Type		Pitting	Blistering	Under-cutting	Protection	Corrosion
					I	II					
A-8	1										
	2	4	10	10	10	10	H	10	10	3	-
	3	0*	-	-	-	-	-	-	-	-	-
A-8-E	1										
	2	10	10	10	10	10	-	2/F	10	10	10
	3	10	2/F	10	10	10	-	2/F	L	9+	L
A-8-V	1										
	2	10	10	10	10	10	10	10	10	10	10
	3	9	10	10	10	10	-	2/M	L	9+	VL
A-8-T	1										
	2	9+	10	10	10	10	-	10	10	10	10
	3	9+	10	10	10	10	-	2/M	L	9	L
A-8-P	1										
	2	10	10	10	10	10	-	2/F	10	10	10
	3	10	10	10	10	10	-	2/F	L	9+	VL
	1										
	2										
	3										

Remarks; *Corrosion over 100% of Surface.

APPENDIX D

RATING OF COATING SYSTEMS

System	Years Exposed	Unscribed Surface						Scribed Surface			
		Protection	Blistering	Undercutting Edges	Rusting Type I	Rusting Type II	Pitting	Blistering	Under-cutting	Protection	Corrosion
A-9-E	1										
	2	9+	10	10	10	10	-	2/F	VL	9+	10
	3	9	10	10	10	10	-	2/D	M	8	M
A-9-V	1										
	2	9+	10	10	10	10	-	2/F	10	9+	10
	3	9	10	10	10	10	L	2/D	M	7	L
A-9-T	1										
	2	4	10 *	10	10	10	-	10 *	M *	6	M
	3	0	2/D	10	10	10	L	2/D	H	0	H
A-9-P	1										
	2	9	10	10	10	10	-	10	M	8	M
	3	8	10	10	10	10	-	2/D	M	4	H
	1										
	2										
	3										
	1										
	2										
	3										

Remarks; * General loss of bond-probably blistering.

APPENDIX D

RATING OF COATING SYSTEMS

System	Years Exposed	Unscribed Surface						Scribed Surface			
		Protection	Blistering	Undercutting Edges	Rusting Type I	Rusting Type II	Pitting	Blistering	Under-cutting	Protection	Corrosion
A-10-P	1										
	2	9	10	10	10	10	L	10	10	7	H
	3	0 1/	0	0	0	0	M	0	0	0	H
A-10-T	1										
	2	2 1/			10	10	H	10	10	4 1/	M
	3	0	-	-	-	-	L	-	H	0	-
A-10-V	1										
	2	5	-	-	10	10	H	-	-	5	VL
	3	0	2/F 2/	-	-	-	-	2/D 2/	M 3/	0	L
A-11	1										
	2	10	10	10	10	10	-	10	10	9+	VL
	3	9	10	10	10	10	M	10	10	9	VL
A-11-E	1										
	2	9+	10	10	10	10	-	10	10	9+	VL
	3	9	10	-	10	10	-	2/M	VL	8	L
A-11-T	1										
	2	8	4/	10	10	10	L	2/M	M	8	L
	3	2	-	-	-	-	-	2/D	H	5	H

Remarks:

1/ Medium dense pitting probably caused by barnacles.
2/ General loss of bond - mostly starting at damage at scribe.
3/ Slight fouling damage.
4/ Two large blisters (also on back side).

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Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Naval Civil Engineering Laboratory Port Hueneme, California 93043	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

ZINC-RICH COATINGS FOR ALUMINUM IN SEAWATER

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Not final, 1969-1972

5. AUTHOR(S) (First name, middle initial, last name)

Carl V. Brouillette

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
August 1973	54	5

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. YF 54.543.006.01.002	Technical Note N-1291
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

10. DISTRIBUTION STATEMENT Distribution limited to U. S. Government agencies only; test and evaluation August 1973. Other requests for this document must be referred to the Naval Civil Engineering Laboratory.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Naval Facilities Engineering Command, Alexandria, VA 22332

13. ABSTRACT

Aluminum 6061-T6 coated test panels were prepared for exposure in the harbor water at Port Hueneme, California. Surface preparation of most of the panels was by a light sandblast before application of selected coatings; but one series was merely washed clean with water and then with mineral spirits, and another was treated with Alodine 1200S before the coatings were applied. Zinc-rich primers of various types were used, topcoated with epoxy vinyl or coal-tar epoxy systems. After three years of exposure coatings over the Alodine 1200S gave good to excellent protection comparable to that over the zinc inorganic silicates. The topcoated zinc-rich organic primers were slightly inferior to the zinc inorganic silicates. Several coating systems gave excellent protection during the three years of harbor exposure and indicated a protective potential for several years more.

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S/N 0101-807-6801

Unclassified

Security Classification

Unclassified
Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Aluminum						
Zinc coatings						
Epoxy coatings						
Seawater corrosion						
Corrosion environments						

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